Statement of

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Before the

Subcommittee on Aeronautics and Space Policy Institute
Of the Committee on Science

Meeting State and Local Needs for Space-based Data and Information

Kansas City, KS
May 20, 2002

Mr. Chairman and Members of the Subcommittee on Aeronautics and Space of the House Science Committee. Thank you for this opportunity to testify concerning how space technology and data can help meet state and local needs. Most of my academic career, beginning in 1981, has focused on the application of remotely sensed data and geographic information systems (GIS) for addressing a variety of environmental and agricultural issues. During the past decade, a majority of my research activities have focused on the use of remotely sensed data for forecasting yields of major row crops throughout the U.S. I have chosen to focus on agriculture because of its economic importance in the Midwest and the general well-being of people in the U.S. and throughout the world. Knowledge concerning the condition, productivity and availability of our agricultural resources is critical to the decision making process at all levels of the food distribution chain. The importance of such knowledge is been well stated by the Institute for Agriculture and Trade Policy.

To have a secure supply of food, both in its quality and safety, has been a primary goal of humankind since the dawn of our species. Food, next to life itself, is our greatest common denominator. Its availability, quality, and price are matters of life and death, and the cultures it nourishes, its moral and religious significance, make it history s staff of life as well. (Karen Lehman, Institute for Agriculture and Trade Policy, February, 1995).

The U.S. is the largest exporter of agricultural products in the world. It is estimated that in 2001, our agricultural exports totaled $54.5 billion (USDA AES-32, Nov. 30, 2001). The economic well-being of the U.S. is obviously strongly linked to agricultural supplies and demands.

Perhaps no region of the U.S. is tied more closely to agriculture and its economic impacts than the Great Plains. Amber waves of grain and Home on the Range are verbal and graphic images that accurately describe the landscape and the economy of this key region within America s heartland. The 10 Great Plains states account for 87% of the nation s grain sorghum (milo) production, 61% of its wheat, and 21% of its corn. Its vast grasslands support 60% of the nation s cattle and calves and approximately 75% of its feeder cattle.

Within the Great Plains resides one of the most vulnerable agroecosystems in the American northern hemisphere. Wide annual and inter-annual variations in weather strongly influence crop and range production, and even subtle shifts in the temporality or quantity of precipitation can have major impacts. High summer temperatures and strong winds combine to create high evapotranspiration rates, while early fall and late spring freezes add further unpredictability. Although the region enjoys world prominence in grain and cattle production, the Plains agricultural resources are highly susceptible to both short- and long-term climate fluctuation.

A clear example of the region s vulnerability is seen in recent wheat harvest statistics for two states in the central plains. Optimal climatic conditions in 1994 resulted in a winter wheat harvest of 576 million bushels in Kansas and Oklahoma. The following year, a late spring freeze and subsequent excess precipitation reduced the harvest to 395 million bushels, and in 1996 a severe spring drought reduced the harvest to just 348 million bushels. One year later, in 1997, near-ideal growing conditions produced a record harvest of 684 million bushels. Such weather extremes, experienced over just four years, demonstrate the sensitivity of crop production in this region to climatic variation. The impacts of wide swings in crop production affect not just primary producers and end users, but a wide range of enterprises and people reliant on a successful and reliable agricultural economy.

Remote Sensing for Monitoring Crop Condition and Yields

While we have little control over the impacts of weather on our crops, through remote sensing technologies developed at NASA, we now have the ability to monitor and assess the impacts that weather is having on crops. Such information is critical to reducing economic risk, and the sooner this information is available, the lower the risk throughout the food distribution network translating into greater efficiency and increased return on investments.

For approximately 50 years, the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) has produced a monthly crop report of estimated U.S. yields. The statistics for this report are generated from national mail surveys, farmer interviews, and field office reports. From these data, NASS produces a yield estimate for each Crop Reporting District (CRD) within a state (e.g., Kansas has nine CRDs). Since a CRD in the Great Plains Region often covers an area as large as 10,000 square miles, there is considerable variation in yields within a district as demonstrated for the state of Kansas (Figure 1).

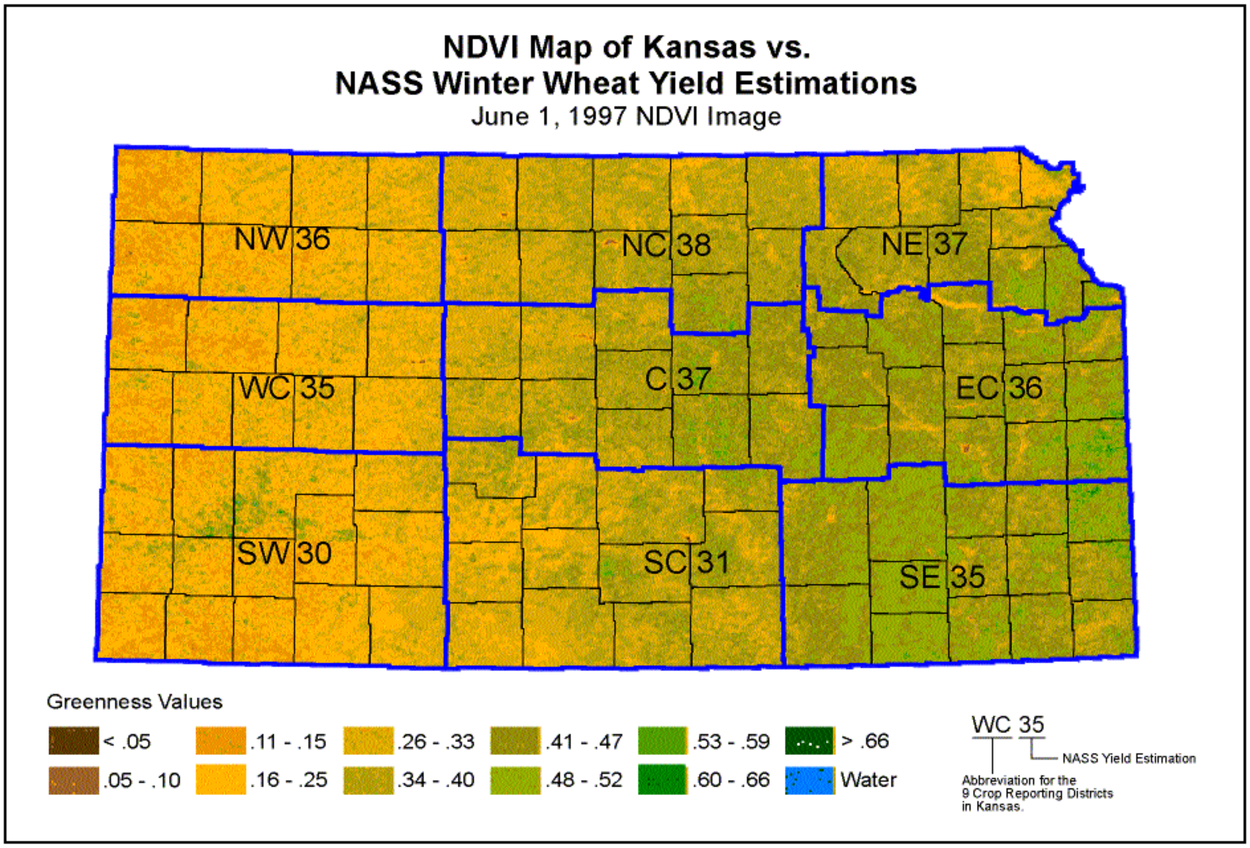

Figure 1. Colors within each CRD in Kansas indicate variations in vegetation vigor (green = higher biomass, yellow = lower biomass). NASS yield estimates are overlaid on each CRD (For example, the winter wheat estimate for the northwest (NW) CRD is 36 bushel per acre).

USDA personnel are well aware of the limitations associated with the present crop reporting system, and are continually investigating new methods for improving the reporting process. As a result of input from USDA officials and others who depend on crop forecast information, several useful improvements could be made by:

1. **Providing earlier and more frequent condition and yield information**. Crop yields can change dramatically from week to week due to weather, pests, disease, and other factors. Bi-weekly estimates, therefore, would improve the ability to monitor changes in yields in near-real time.

2. **Providing condition and yield estimated for smaller geographic areas**. As seen in Figure 1, CRD-level yield estimates provide little information about individual counties within each CRD. County-level estimates would improve the ability to identify and assess changes in crop yields for smaller geographic areas. This would improve the overall ability to assess and locate potential production surplus or deficit areas within each CRD. Such information could improve such things as the harvest, storage, marketing, and crop transportation planning process.

3. **Provide condition and yield reports in map and tabular formats**. Tabular estimates provide a coarse-grained view of yields and are important for conducting basic statistical analysis. The availability of crop condition and yield information in both map and tabular formats would make it easier to identify over- or under-producing areas. Additionally, information about crop yield distribution patterns within CRDs could be shown, thus improving the ability to determine areas most impacted by weather conditions and destructive events such as frost, hail, pests, and disease.

For over 30 years, the Kansas Applied Remote Sensing (KARS) Program at the University of Kansas in Lawrence has been conducting applied research for federal, state, local government and private organizations. In 1995, we began using satellite remotely sensed data to produce weekly maps showing relative vegetation condition (called the *GreenReport*®) throughout the conterminous U.S., and beginning in 2001, biweekly crop yield forecasts for nine crop types (Table 1 and Figure 2).

Table 1 shows the crop types and coverage for which satellite remotely sensed data are now being used by the KARS Program to forecast yields within the conterminous U.S.

CROP	**2001 coverage**
winter wheat	42 states, 270 CRDs, US
corn for grain*	41 states, 263 CRDs, US
soybeans*	29 states, 200 CRDs, US
barley	27 states, 127 CRDs, US
upland cotton	16 states, 73 CRDs, US
spring wheat	12 states, 65 CRDs, US
sorghum	18 states, 105 CRDs, US
duram spring wheat	6 states, 19 CRDs
pima cotton	4 states, 5 CRDs

* Forecasts for this crop beginning in 2001 will include additional coverage at the county level, beginning with all of the counties in Iowa.

The development of the *GreenReport*® and the models for estimating crop yields was jointly funded by the NASA Earth Science Applications Research Program (ESARP) and several private companies. As a result of NASA s support, the KARS Program has been able to build up a strategic network of key public and private sector partners who are willing to commit both time and funding to commercialize remote sensing-derived products. The combined resources and expertise of this partnership network has allowed the process of research, commercialization, outreach, and technology transfer to proceed successfully in an environment that both distributes and minimizes risk to the parties involved.

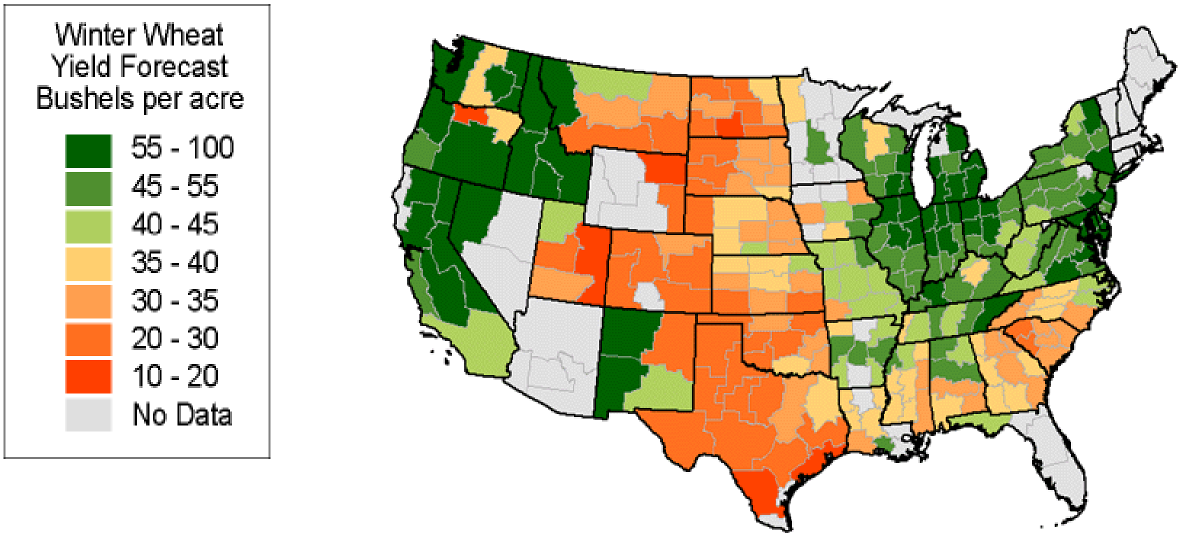

Figure 2. Winter wheat yield forecast for the conterminous U.S. as of May 13, 2002. This forecast was made using only satellite remotely sensed data as input to the yield forecasting model.

NASA's applied research support has also enabled KARS to develop new applications for government agencies. In 2001 and 2002, for example, KARS scientists began the creation of a series of new rangeland and water resource management initiatives, strengthening the ongoing technology transfer to state and local governments. Each of these new applications initiatives was pursued on the basis of user needs assessments from the appropriate user group decision-makers.

The purpose of academic research is thought by many to be for the acquisition of knowledge, but actually the ultimate purpose for acquiring knowledge is usually for the betterment of society. Thus, one of our goals as academic scientists should be to foster the transfer of knowledge to society. One of the primary challenges facing an academic research unit like the KARS Program is to improve the means for transferring knowledge to the private and public sector as quickly as possible. We have learned that more expedient transfer of knowledge is achieved through the establishment of a public and private sector network of partners willing to commit the time and financial resources necessary to support the technology transfer cycle. Of particular importance is identifying partners who are willing to provide support and resources across the entire cycle-including initial research, development of proof-of-concept applications, subsequent applied research and prototype development, and all of the associated test marketing, evaluation, and product distribution activities that are required to develop a fully operational commercial and/or decision support product. This process is described as a cycle because end-user feedback is critical to directing subsequent research activities.

There are three primary obstacles uniquely associated with developing new remote sensing applications that must be addressed before the technology can be successfully transfer to public or private end users. These include:

* **High startup costs.** The equipment and staff resources required to develop a new prototype remote sensing-derived product, once a promising application has been demonstrated, can cost hundreds of thousands of dollars. Consequently, remote sensing product development is often characterized by high startup costs.

* **High risk.** High startup costs, combined with uncertain market potential, are associated with high risk. This is particularly true in market sectors for which there are no existing or widely used remote sensing applications, and thus whose commercial potential cannot be fully demonstrated to potential development partners or end users.

* **There are no overnight successes**. Creating a marketable commercial remote sensing product requires intensively interactive and time-consuming research and development activity. Our experience, and that of our commercial partners, has been that 7-10 years is a reasonable expectation level for full commercial product development in response to user needs.
The combined consequence of these challenges is that potential investment partners are reluctant to accept high startup costs, bear potentially significant financial risks, and sustain a workforce in an endeavor whose financial returns are initially uncertain. Overcoming this reluctance and securing private sector support across the life of the product development cycle requires both time and creativity. Creative technology transfer models must be developed to help businesses bear expensive remote sensing startup costs while the market is developed.

We believe that a key link to the technology transfer cycle is the establishment and continued support of applied remote sensing research. Applied research is sometimes confused with commercial product development. As demonstrated in Figure 3, however, applied research provides a critical link between fundamental research and commercialization (product development). Without this important link, the transfer of knowledge is greatly suppressed which means the time from conception of ideas until the ideas are transferred to the end users (tax payers) is greatly increased. Some believe that applied research should be supported mostly by the private sector and government agencies that require such research. Unfortunately there are many barriers, including lack of government agency funding, and risk and confidentiality concerns by the private sector, that limit applied research activities in the U.S. To my knowledge, NASA is the only government agency with an applied research program. Ironically, it is often the applied research results that are presented to government representatives as various agencies attempt to justify their budget requests. This is because representatives of the people want to know what government organizations are doing for their constituents. The benefits of applied research are usually more easily understood and appreciated by society. Obviously, fundamental research is necessary to sustain applied research. But if more support for applied research were available, the findings of fundamental research could be transferred to the end users more quickly thus creating more job opportunities and allowing tax payers to reap the benefits of their tax dollar investments more quickly.

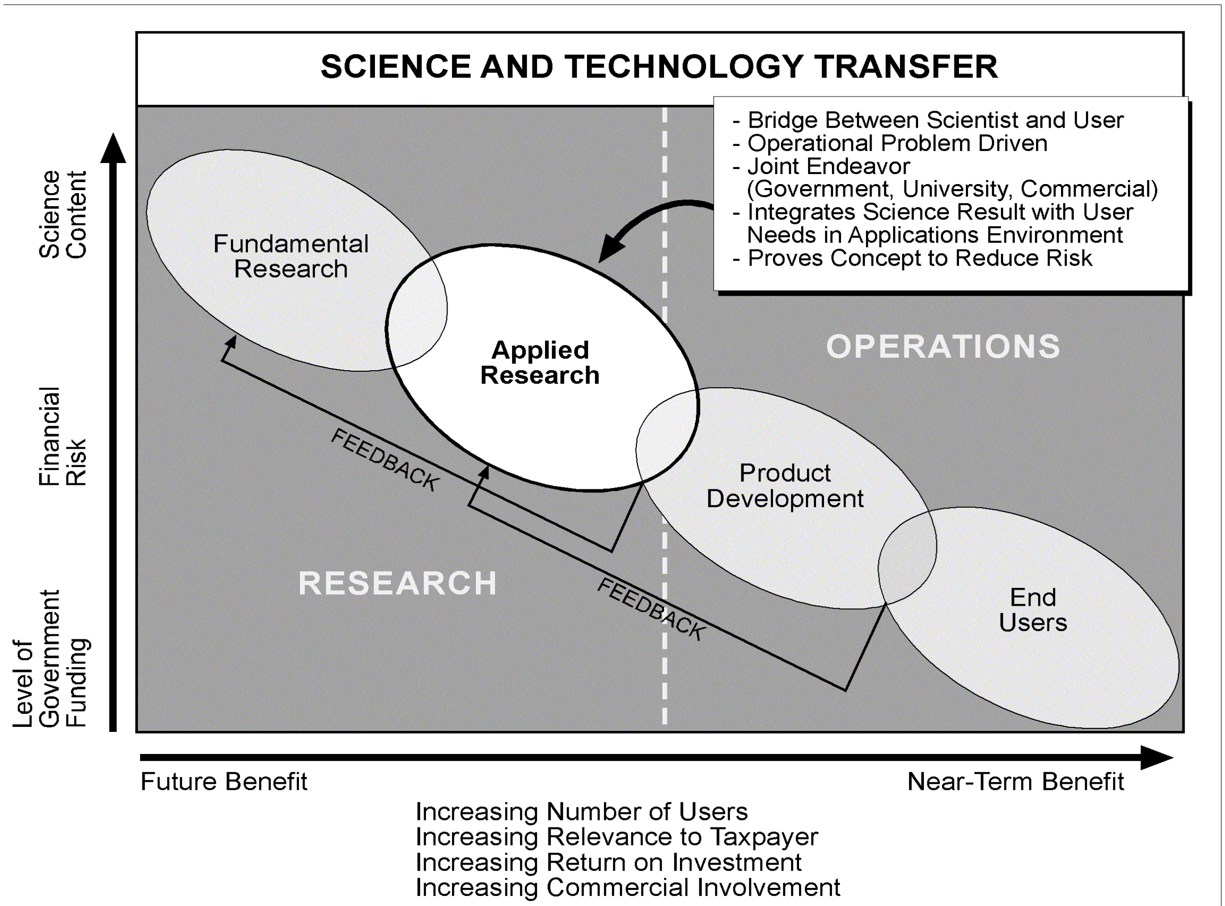

Figure 3. This diagram shows the linkage between Fundamental Research, Applied Research, Product Development, and the End Users. As one moves up the graph, financial risk increases, and as one move towards the right side of the graph, the benefits to society are more quickly realized.

The level of utilization of remotely sensed data for agricultural purposes is strongly tied to the development of applications that use these data. The number of applications are increased through increase applied remote sensing research activities that foster a closer working relationship with the public and private sector, thus insuring that the applied research is guided by end user needs whether it be a private citizen or organization, or a state or local government agency.

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Dr. Kevin Price is a Professor of Geography and Associate Director of the Kansas Applied Remote Sensing Program at the University of Kansas. His has a B.S. and M.S. from Brigham Young University in Botany and Range Science and received his Ph.D. in 1997 in Geography from the University of Utah where he specialized in advanced digital image processing of satellite remotely sensed imagery. He has authored or co-authored 225 publications, has 159 scientific papers presents, and is principal/co-principal investigator on 73 grants/contracts totaling over $21 million. He has ongoing research and educational activities in the US Great Plains, Central Asia, Mexico, Central America, and South Central Africa. His research focus is on land cover and use characterization, crop condition and yield assessment, and earth system studies using observations made from satellite remote sensing instruments. He is presently serving on the National Research Council committee for Agenda 21 and is helping draft recommendations to the U.S. State Department relative to sustainable development in Africa.

<u>SELECTED HONORS</u>:

- **2001-2002 National Research Council**, Geographical Foundation for Agenda 21 on Sustainable Development in Africa, Committee Member,
- ***State of Kansas Earth Systems Science Leader***, 1997- 2000
- ***Editorial Committee Member,*** 1996 - present, GeoCarto International
- ***Distinguished Lecturer,*** 1996 - present, Kansas Academy of Sciences
- ***Chair***, 1996 - 1998, Association of American Geographers, Remote Sensing Specialty Group; ***Recipient of the 1993 & 1994 Meritorious Service Award***, American Society of Photogrammetry and Remote Sensing;
- ***NASA Global Climate Change Fellowship***, NASA Summer School for Earth Science: Processes of Global Change, 1990;

<u>RECENT PUBLICATIONS</u>:

Wang, J., K.P. Price, and P.M. Rich. 2001. Spatial patterns of NDVI in response to precipitation and temperature in the central Great Plains. *International Journal of Remote Sensing* 22/18:3827-3844 .

Price, K.P., T. Crooks, and E.A. Martinko. 2001. Grasslands across time and scale: A remote sensing perspective. April Conference Edition 2001 Highlight Article, *Photogrammetric Engineering & Remote Sensing*, 67(4):414 - 419.

Guo, X., K.P. Price, and J.M. Stiles. 2000. Biophysical and spectral characteristics of cool- and warm-season grasslands under three land management practices in eastern Kansas. *Natural Resources Research,* 9(4):321-331.

Griffith, J., K.P. Price, and E.A. Martinko. 2001. A multivariate analysis of biophysical parameters of tallgrass prairie among land management practices and years. *Environmental Monitoring and Assessment.* 68:249-271.

Griffith, J., E.A. Martinko, and K.P. Price. 2000. Landscape structure analysis of Kansas at three scales. *Landscape and Urban Planning.* 52(11):45-61.

Guo, X., K.P. Price, and J.M. Stiles. 2000. Modeling biophysical factors for grasslands in Eastern Kansas using Landsat TM data. *Transactions of the Kansas Academy of Science*, 103(3-4):122-138.

Jakubauskas, M.E., K. Kindscher, A. Fraser, D.M. Debinski, and K.P. Price. 2000. Close-range remote sensing of aquatic macrophyte vegetation cover. *International Journal of Remote Sensing,* 21(18):3533-3538.

Ortega-Huerta, M.A., E. Martinez-Meyer, S.L. Egbert, K.P. Price, and T.A. Peterson. 2000. Mapping the land cover of Mexico using AVHRR time-series data sets**.** *GeoCarto International,* 15(3):5-17.

Martinko, E.A., K.P. Price, S.L. Egbert, J.L. Whistler, M.E. Jakubauskas, and T.J. Crooks. 2000. Building on three decades of remote sensing and decision support: the NASA Great Plains RESAC and the Kansas Applied Remote Sensing (KARS) Program. October 2000 Highlight Article *Photogrammetric Engineering & Remote Sensing*, 66(10):1158-1163.

Peterson, A.T., S.L. Egbert, V. Sanchez-Cordero, and K.P. Price. 2000. Geographic analysis of conservation priority: Endemic birds and mammals in Veracruz, Mexico. *Biological Conservation*, 93:85-94.

Jakubauskas, M.E., and K.P. Price. 1999. Regression-based estimation of lodgepole pine forest age from Landsat Thematic Mapper data. *GeoCarto International,* 15(1):19-24.

Bork, E.W., N.E. West, and K.P. Price. 1999. Calibration of broad- and narrow-band spectral variables for rangeland cover component quantification. *International Journal of Remote Sensing*, 20(18):3641-3662.

Bork, E., N.E. West, K.P. Price, and J.W. Walker. 1999. Rangeland cover component quantification using broad (TM) and narrow-band (1.4 NM) spectrometry. *Journal of Range Science*, 52:249-257.

Nellis, M.D., and K.P. Price. 1998. The sustainability of rural land use systems in Western Kansas: Myth or reality? Pp. 115-118 in *Dimensions of Sustainable Rural Systems.* Bowler, Bryant, and Huigen (eds), Nederlandse Geografische Studies 244, Utrecht/Groninge (Book chapter).

Egbert, S.L., A.T. Peterson, K.P. Price, and V. Sanchez-Cordero. 1998. Modeling conservation priorities in Veracruz, Mexico. Pp. 141- 150 in *GIS Solutions in Natural Resource Management - Balancing the Technical-Political Equation.* S. Morain (ed), High Mountain Press, 364 pp. (Book chapter).

Bork, E., K.P. Price, and N.E. West. 1998. *In-Situ* narrow-band reflectance characteristics of cover components in sagebrush steppe. *GeoCarto International*, 13(4):5-15.

Egbert, S.L., R.-Y. Yang, K.P. Price, M.D. Nellis, and R. Boyce. 1998. Mapping Conservation Reserve Program (CRP) grasslands using multi-seasonal Thematic Mapper imagery. *GeoCarto International*, 13(4):17-24.

Price, K.P., and M.E. Jakubauskas. 1998. Spectral retrogression and insect damage in lodgepole pine successional forests. *International Journal of Remote Sensing,* 19(8):1627-1632.

Egbert, S.L., R.-Y. Lee, K.P. Price, R. Boyce, and M.D. Nellis. 1997. Mapping the Kansas grasslands: A multi-temporal approach. *GAP Analysis Bulletin*, 6:12-13.

Price, K.P., S.L. Egbert, M.D. Nellis, R. Lee, and R. Boyce. 1997. Mapping land cover in a High Plains agro-ecosystem using a multidate Landsat thematic mapper modeling approach. *Transactions of the Kansas Academy of Science*, 100(1-2):21-33 (Invited paper) www address: http://www.emporia.edu/S/www/kas/transact/sympos96/price/price.htm.

Wu, J., M.D. Nellis, M.D. Ransom, K.P. Price, and S.L. Egbert. 1997. Evaluating soil properties of CRP land using remote sensing and GIS in Finney County, Kansas. *Journal of Soil and Water Conservation*, 52(5):352-358.

Jakubauskas, M.E., and K.P. Price. **1997.** Empirical relationships between structural and spectral factors of Yellowstone lodgepole pine forests. *Photogrammetric Engineering & Remote Sensing*, 63(12):1375-1381.

The Honorable Dana Rohrabacher May 17, 2001
Chairman
Subcommittee on Space and Aeronautics
Committee on Science
U.S. House of Representatives
Suite 2320 Rayburn House Office Building
Washington, DC 20515-6301

Dear Representative Rohrabacher:

This letter of financial disclosure is submitted in connection with the hearing to be held on May 20, 2002 in Kansas City, Kansas, in accordance with the Rules of the House of Representatives that require that each person who testifies disclose sources and amounts of federal funding (by agency and program) which directly supports the subject matter. Funds received by me or entities I will represent during the current and two previous fiscal years include the following:

National Aeronautics and Space Administration. Office of Earth Science. The Great Plains Regional Earth Science Applications Center (GP-RESAC): A Consortium to Transfer Remote Sensing Products and Technology to Support the Great Plains Agroecosystem. 1999-2003. $1,550,000

National Aeronautics and Space Administration. Office of Earth Science. Remote Sensing-based Geostatistical Modeling for Coniferous Forest Inventory and Characterization. 1999-2002. $560,000.

National Aeronautics and Space Administration. Office of Earth Science. Research in the Incubation of Commercial Remote Sensing Products. 1999-2003. $450,000.

National Aeronautics and Space Administration. Office of Earth Science. Linking Remote Sensing, Land Use, and Carbon Sequestration: Insights from Leaf to Landscape Scales in America s Heartland. 2001-2003. $997,800.

If you have additional questions regarding this information, please let me know.

Sincerely,

Kevin P. Price
Associate Director